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INCREASING THE FIRE RESISTANCE OF TIMBER STRUCTURES AND BUILDINGS USING MODEL TESTS WITH FIRE RETARDANTS

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Today, an urgent problem in modern construction is the development of highly functional fire-resistant solutions to protect the timber from destruction and the effect of fire on it, which are characterized by the high efficiency of the penetration of these solutions into the middle of the timber, the durability of their protection and operational properties to ensure the longevity of the operation of timber structures. One of these fire-resistant solutions is a solution invented on the basis of the method of impregnation of timber based on area.

In this work, we provide an analysis of modern methods of calculated tests regarding the quality of impregnation of timber structures and timber products made of timber with protective fire-resistant solutions (fire retardants), as well as the schemes of these model tests.

Keywords: timber, timber structures, fire-resistant solutions, fire, samples, flame-retardants.

Introduction

In order to determine operational resistance to protect the properties of refractory solutions (fire retardants) under various operating conditions, the resulting (final) test methods (so-called model polygon tests) are used. It should be noted that such methods are used to determine the ability of fire-resistant solutions (with their different costs) to protect timber for long periods of operation under real natural conditions (Ozarkiv, 2005).

It should be noted that this type of polygon testing of fire-resistant solutions in the classic form, that is, when timber samples interact with fire, is a surprisingly reliable test method. Therefore, the comparative efficiency of such flame-retardants, obtained on the basis of this method, allows us to fully obtain approximate data in order to further establish the number and norms of their consumption; although this kind of test is rather long-lasting. Thanks to this, it is important to obtain general patterns that can be obtained in some terms of these tests and draw conclusions based on the relevant calculations. Therefore, it should be noted that conducting experiments on samples with different cross-sections allows us to obtain results on samples with smaller cross-sections in a shorter period. Although conducting tests of samples with a larger cross-section significantly increases the duration of research, they significantly increase the reliability of the obtained conclusions. Therefore, the obtained conclusions, which were carried out on small samples, can be used only in comparison with the protective ability of fire retardants, and for justification, regarding their consumption norms, can be used only when the dimensions of polygon samples for testing can correspond to construction details and products or structures (Leonovych, 2003). Studies of the properties of fire protection on small bars or small parts, despite the acceleration of the experiment, will constantly reduce the protective capacity of fire retardants for such cases, when in practice the fire-resistant solution (fire retardant) itself will be widely used on larger cross-sections (Ozarkiv, 2003).

The purpose of this study is to increase the fire resistance of timber structures and buildings with fire retardants when using different methods and methods of testing on samples of different types of timber.

Materials and Methods

Testing on non-life-size test samples gives us indicators of only the conditional ability to fire the tested solution of the drug on them.

Accordingly, for the most complete assessment of the properties of these drug solutions, it is necessary to apply many different, both in terms of type and purpose, laboratory and observed methods of testing antipiperine solutions. In particular, so-called express selection methods are needed for primary research – evaluation methods that allow us to conduct research on a large number of their compounds with the least amount of labor and time. In the next stage of experiments on fire protection, functional methods will be used, which serve to identify one or another function of test solutions of preparations. The following characteristics should be attributed to them: the speed of flame spread over the surface of the sample, the amount of heat released during combustion, the oxygen index, etc (Ozarkiv, 2004).

It should be noted that conducting tests using different methods is also necessary because the results of the tests carried out and obtained by us are not always the same, that is, they do not determine the levels of the protective ability of different fire-resistant solutions (flame retardants) in one and the same way (Demchyna, 2011). In addition, the same flame retardant solutions are evaluated differently in different countries of the world. As an example, in the CIS countries, the fire protection ability of one or another flame retardant preparation is tested according to GOST 16363-76, and in the USA – according to ASTM E 69-50. Therefore, samples of samples from pine sapwood in the dimensions of 30×60×150 mm for tests for GOST 16363-76 and 10×20×900 mm according to ASTM E 69-50.

In the course of our analysis of the features of the tests carried out by various methods, it indicates the need and feasibility of developing a single and the most universal method that would fully or maximally reflect the number of factors that have an impact on the combustion process.

Emphasizing that during polygon and other natural tests of fire retardants (flame retardants) on life-size models or structures or, even, in buildings, objectively certain difficulties will always arise, but, nevertheless, only they will give us information about the general laws of fire protection of building material and to facilitate the assessment of the forecast of the fire protection ability of new fireproofing products. It should be noted that tests of fireproof protection of timber structures, although they are carried out quite quickly, are not always carried out and not on a sufficient scale. However, it is also necessary to recognize the effectiveness of pavilion tests of the flame retardant properties of flame-retardants on models that simulate given fire conditions (Gorbachova, 2006).

Results and discussions

The most common methods of testing models are suggested to be focus on.

”Method of testing flame-retardant properties on models” (GOST-24617-81), which consists in determining the mass loss and burning time of the “board pipe” model when it is burned in an open area. In this case, a model of pine timber is used, which is made of four boards measuring 40×200×500 mm with a layer of 160×160 mm, which were previously impregnated with one of the fire retardant solutions. The source of ignition is the so-called “impulse”, consisting of 200 g of shavings and 200 g of white alcohol. After the “impulse” is set on fire, the duration of resistance of the given model that is set on fire is determined with the help of a stopwatch, as well as the duration of burning with flame, smoldering and burning until the moment of charring of the model. We draw your attention to the fact that the tests of each flame-retardant preparation are carried out on no less than three models that have the same absorption of the flame-retardant solution (flame retardant) (Ozarkiv, 2005).

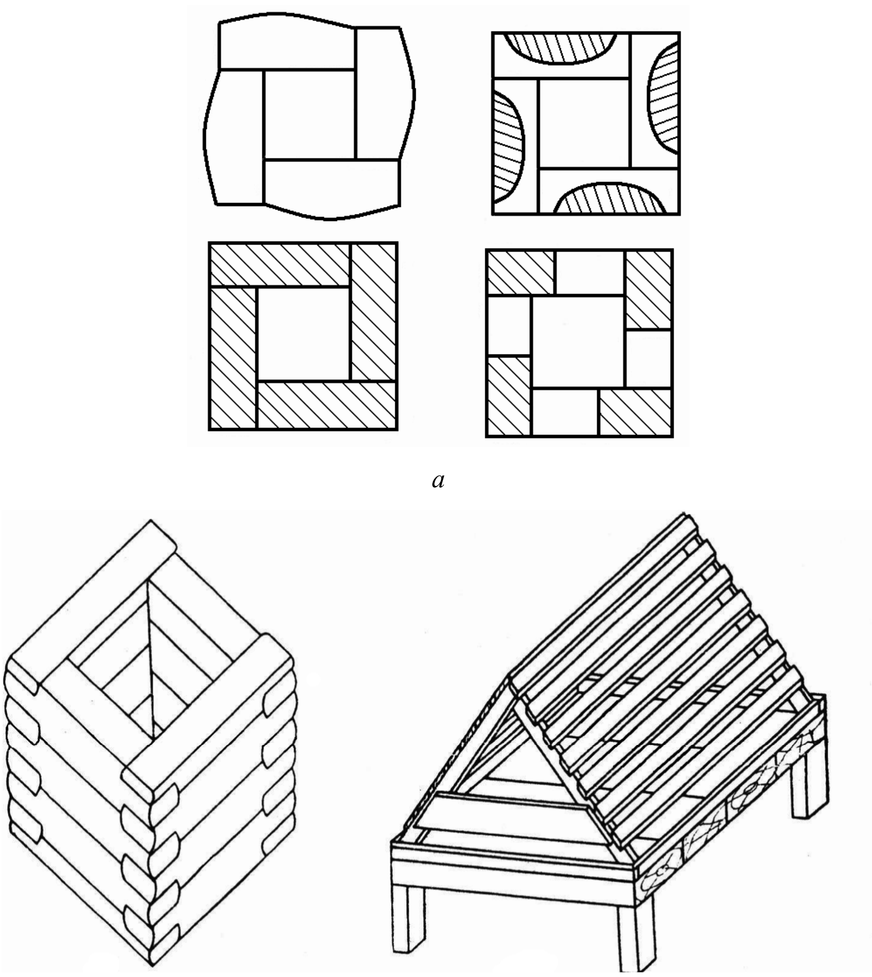
Depending on the test tasks set by us, boards of different sizes, as well as the nature of sawing and condition, can be used. Tests conducted in relation to a new fire-retardant material should be carried out on pure sapwood boards (which, in turn, are quite difficult to select) or on mixed sawn boards, but with such a calculation that they all have the same ratio and location of LPZ and TPZ (Fig. 1).

The dimensions of the pipes and the thickness of the boards can be changed.

For preliminary tests, when we need a lot of pipes, you can make pipes from relatively thin and narrow boards (25×120 mm, 40–160 mm).

In this case, the height of the pipe should be equal to 30 and 40 cm, respectively. For the final (final) tests, it is useful to increase the dimensions of the boards and pipes (for example, use boards 40×170 mm or 50–200 mm, 50, and 70 cm long, respectively). 50–200 g of twisted timber shavings and the same amount of fuel (white spirit) are used as kindling (Ozarkiv, 2004).

The pit well method (Fig. 1, *b*) is used to determine the combustion characteristics of coarse timber elements that are soaked to a small depth compared to their thickness. For these models, round logs are used, densely chopped, for example, into a "paw" (Fig. 1, *b*). The dimensions of the models themselves and the diameter of the log segments can be different, but for one experiment or a series of such experiments, they must have the same dimensions (for example, 1×1×1 m with a diameter of the log segments of 15–30 cm. The kindling (its composition includes 1000–1200 g of shavings and 600–800 g of fuel) is made and installed in the model in the same way as in the "board pipe" method. Under this condition, the control model (depending on the wind speed and the diameter of the logs) burns in 2–3 hours and burns completely. Due to the fact, that the percentage of timber that is unprotected in log models is significant, in this case tests with weighing the residue are impractical, they should be carried out taking into account water consumption and duration of extinguishing, as well as determining the depth of burning of the walls (Peretyatko, 2003).



a

b *c*

Fig. 1. Scheme of model tests of flame retardant properties of flame retardant solutions (fire retardants):a – the method of the timber pipe (shaded TPZ in the details of the model, non-shaded lightly permeated zone – LPZ); b – well method (well); c – method of the "overlap – roof" model

The next method of the "roof – overlap" model (Fig. 1, c), which is used in laboratory conditions and is carried out in two directions, namely: for testing fire protection in the conditions of roof coverings and for testing the resistance of the overlap against its burning. This model consists of two parts (the roof and the ceiling), which includes the strapping, rafters and crate. Chip igniter (200 g of chips, 200 g of fuel is directly placed on a special shelf). In order to prevent fuel from getting on the ceiling, it is kept outside the model for a few minutes, and later it is placed on a paper backing and only after that, it is introduced into the model.

Therefore, taking into account the above, it is possible to generalize and specify as requirements the following test methodology for the details of the model or assembly model, as well as the course of the test itself, that is, the methodology (Ozarkiv, 2003).

Among them, the following should be highlighted:

1) samples or parts of the model are impregnated with fire-resistant solutions (fire retardants) and dried to a humidity of 16–22 % (according to control), depending on the weather and the type of protective preparation;

2) in order to achieve certain and the same for all models of aeration during the combustion process, they are installed on low-flammable stands of low height, and are closed from above with shutters made of sheet metal (construction steel) in order to evenly distribute and direct the movement of air and combustion products;

3) the power of the necessary igniter is determined in accordance with the specific conditions of experience with such a calculation that it is enough to ignite the control of the models and its subsequent self-burning (very weak and strong igniters reduce the sensitivity of the method and, thus, reduce the effectiveness of the most refractory flame retardant solutions);

4) the fire source used for setting fire directly in the model is lighters, which include:

– twisted shavings of equilibrium atmospheric humidity;

– weakly smoky and combustible liquid that gives off a lot of smoke (white spirit);

– a cotton swab, which corresponds to the size and shape of the capacity of one or another model and is placed inside it on a pallet or sheet of metal;

– the fuel itself is evenly distributed over the weighted amount based on the calculation of its leakage.

5) in order to measure the dynamics of the combustion temperature on its separate bases thermocouples are installed, which are connected to the potentiometer;

6) the models are ignited at the same time and are burned to the end without interfering with their combustion process. At the same time, in stages, the characteristics of burning and temperature, and only after that, to obtain the final test result, the remains of burnt timber are weighed after the completion of the burning process itself;

7) in the event that impregnation with a refractory solution does not extend to the entire depth of the burning material, the difference in the fire resistance of different models, previously protected with a refractory solution of different efficiency, is smoothed out due to the burning of the protective coating and the further occurrence of mixed combustion of protected and unprotected timber;

8) taking into account the latter, to take into account the effect of protection for a certain period of time, which is set in advance or during the course of experience, then at a certain moment, the models are equally extinguished with water or a fire extinguisher, taking into account the time and amount of the product that is extinguished;

9) when conducting tests on such models, special attention should be paid to smoldering, which is hidden and difficult to observe the stage of combustion (Peretyatko, 2003).

Conclusions

During the analysis of the features of the tests carried out by various methods, it was pointed out the need and feasibility of developing a single and the most universal method that would fully or maximally reflect the number of factors influencing the combustion process.

2. The work presents and describes the most common methods of testing timber materials and structures on models of various sizes.

3. The test methodology was selected for the details of the model or assembly model, as well as the course of the test itself, that is, the methodology.

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ПІДВИЩЕННЯ ВОГНЕСТІЙКОСТІ ДЕРЕВ’ЯНИХ КОНСТРУКЦІЙ ТА СПОРУД ЗА ВИКОРИСТАННЯ МОДЕЛЬНИХ ВИПРОБУВАНЬ АНТИПІРЕНАМИ

В сучасному домобудуванні існує безліч проблем, щодо руйнування дерев’яних будівельних конструкцій та споруд під впливом на них не тільки шкідників, які руйнують деревину, а також різноманітних факторів навколишнього середовища та вогню. Найбільш небезпечним з цих проблем та факторів, являється насамперед вплив вогню на деревину, після якого деревина повністю згоряє, і подальше її використання стає неможливим.

Сьогодні найактуальнішою проблемою вирішення цих проблем в сучасному будівництві є винайдення, підбір та розробка високофункціональних вогнетривких розчинів, які б дали змогу захистити деревину від її руйнування, а також дії на неї вогню. Такі вогнетривкі розчини антипіренів характеризуються насамперед високою ефективністю їх проникнення всередину деревини, довговічністю експлуатації, а також експлуатаційними властивостями для забезпечення довговічності експлуатації дерев'яних конструкцій. У світі існує багато способів та методів захисту дерев'яних будівельних конструкції, але й існує проблема в пошуку та винайденні нових складів вогнетривких розчинів, які б дали нам змогу легко просочувати ними деревину, були економічно доступними, екологічно нешкідливими та забезпечували довговічність захисту дерев'яних конструкцій від вогню.

Провівши низку досліджень в пошуках вогнетривкого розчину, який підходить під обраний нами метод випробування вогнезахисних властивостей на моделях, ми дослідили, що одним із таких вогнетривких розчинів, являється розчин, який винайдений на основі методу просочування деревини на основі карбаміду.

В цій роботі нами наведений аналіз сучасних методів налічених випробувань щодо якості просочення дерев'яних конструкцій та виробів з деревини захисними вогнетривкими розчинами (антипіренами), а також наводяться схеми цих модельних випробувань.

Ключові слова: деревина, дерев'яні конструкції, вогнетривкі розчини, вогонь, взірці, антипірени.